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CONCERNING THE DETERIORATION AND SALVAGE

OF INSECT-KILLED PONDEROSA PINE TREES

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March 1, 1941

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CONCERNING THE DETERIORATION AND SALVAGE OF INSECT-KILLED PONDEROSA PINE TREES

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CONCERNING THE DETERIORATION AND SALVAGE OF INSECT-KILLED PONDEROSA PINE TREES

INTRODUCTION

This report had its inception in a letter dated December 16, 1940, to Mr. F. P. Keen from Mr. A. T. Hildman, Forester for the J. Neils Lumber Company, Klickitat, Washington. This letter was written to inform the laboratory that one of the pine beetle survey check plots (the Red Butte plot—T. 6 N., R. 11 E., sec. 13 E/2) in Klickitat County, Wash., was being cut-over by the company. The letter also stated that, in the course of the selective logging operation, the company was cutting all ponderosa pine trees killed in 1940, nearly all of the 1939 trees, and some of the larger 1938 trees, and that the larger logs were more than returning stumpage.

Because of the well known trade prejudice against sap-stained lumber found in insect-killed ponderosa pine trees, it occurred to the writer that here was material for an interesting and timely article for one of the lumber trade magazines. To be most effective, this information should be brought to the attention of forest land managing agencies as soon as possible and during the currently healthy lumber market. Tentative plans were made to prepare an article of joint authorship on this subject by using the loss records on the Red Butte plot and a mill study on several carloads of logs from insect-killed trees made by the company. However, this plan was delayed because: (1) The woods and mill operations of the company were shut down during late December and early January, (2) Unfavorable weather for a field study prevailed in January, (3) The necessity of reviewing previously published information on the subject, and (4) The press of other duties on the part of Mr. Hildman and the writer.

At the present time, a study to secure the necessary data does not seem feasible and has been postponed. Perhaps if the J. Neils Lumber Company cuts over the second check plot (T. 7 N., R. 12 E., sec. 27 N/2) on state-owned land in the Glenwood District, Washington, this plan might be fulfilled.

As a matter of record, the preliminary accomplishments of this plan are herein reported. These are divided into the following four divisions:

I. Resumé of the literature and station reports concerning the deterioration and salvage of insect-killed ponderosa pine trees.

II. What we know of the deterioration and salvage of insect-killed ponderosa pine trees.

III. What we need to know about the deterioration and salvage of insect-killed ponderosa pine trees.

IV. List of articles pertaining to the deterioration and salvage of insect-killed ponderosa pine trees.

I. RESUMÉ OF LITERATURE AND STATION REPORTS* CONCERNING THE DETERIORATION AND SALVAGE OF INSECT-KILLED PONDEROSA PINE TREES

(1) Boyce, J. S. 1923. The deterioration of felled western yellow pine on insect-control projects. U. S. Dept. Agric. Bul. 1140.

This study dealt with the cause of and rate of deterioration and the percentage of cull in ponderosa pine trees treated by the fell-peel-burn method of insect control.

Boyce found that the outer layer of sapwood, having been burned in the treating work and being too dry to decay, remained hard and sound for several years, while the remainder of the sapwood and heartwood deteriorated very rapidly. The following rates of deterioration were given in graphic form:

Seasons of exposure	Percentage of cull
1	18
2	60
3	75
4	81
5	85
6	88
7	92

A season of exposure was defined as the number of growing seasons elapsing since the trees were felled.

*Material in the files of the Portland Forest Insect Laboratory.

(2) Keen, F. P. 1929. Report of insect control work carried out by Pickering Lumber Company on the Badger Sale Area, Modoc National Forest, California, during the season of 1928-1929. Station Report August 13, 1929.

Under the terms of the sale, the company was required to cover 15,000 acres of the sale area during the first year of operation. There were about 17,360 acres and 236,000 M. bd. ft. on the area. On about half of the area (Government ownership) infested trees were felled, peeled, and burned. On the other half of the area the infested trees were felled, trimmed, and skidded to a small mill. At the mill the logs were cut into lumber and the slabs burned. In some cases the logs were brought from a distance of four and five miles, while within a radius of a mile from the mill, all recent beetle killed trees dead for 1-2 years were salvaged and milled. The costs of beetle control by logging and milling were given as follows:

Trees cut	Volume cut	Acres treated	Logging cost only
1994	1,871,614	10,760	$12,315.38 (without overhead, interest or depreciation charges)
Cost per tree	Per Mbm	Per acre	
$6.18	$6.58	$1.14	

On the basis of a value of $8 per Mbm at the mill (about half the value of green logs) this operation resulted in a profit at the mill of $1.42 per Mbm.

(3) Keen, F. P. 1929. Western pine beetle survey Happy Camp-Lava Bed Area, Modoc National Forest, California, 8th Annual Report. Station Report Dec. 18, 1929.

In 1928 the McCloud River Lumber Company moved into the White Horse unit and confined work to a narrow belt along the railroad. In fall they started large scale operations on 121,950 acres and spending $10,914.29. They salvaged 626 trees while 1,721 trees were felled, peeled, and burned. The average cost was $4.65 per tree.

(4) Keen, F. P. 1932. Pine beetle control costs reduced through logging and salvage. U. S. Dept. Agric. Yearbook 1931, pp. 428-430.

Compares the cost of regular fell-peel-burn method of beetle control with the logging of insect-killed ponderosa pine trees.

In 1923, the Weyerhaeuser Timber Company sold the logs left in the woods after the completion of a fell-peel-burn control project. A contractor hauled the logs 5 miles to a small mill and paid $1 for the logs taken. The operation was not profitable.

The Weyerhaeuser Timber Company also purchased a portable sawmill and tried sawing the logs felled in a fell-peel-burn control project into lumber which was in turn hauled to the nearest market. Because the logs were so widely scattered, frequent moves of the mill were necessary and the operation proved to be unprofitable.

In 1928, the Pickering Lumber Company constructed a small mill near the center of an infested area of about 15,000 acres in Modoc County, California. Infested trees were marked by a survey crew, felled, and hauled to the mill in tree lengths. The average haul was about 2 miles. About 2 million board feet were salvaged. The method cost $6.58 per Mbm to bring the trees to the mill and with an estimated value at the mill of $8 per Mbm resulted in a net profit of $1.42 per Mbm (without mill depreciation charges).

In 1929, the McCloud River Lumber Company in Modoc County, California, logged the beetle infested trees, as a method of control, that were within easy reach of their railroad. Tractors were used to skid about 1 million board feet from a strip about 2 miles wide on each side of their tracks. This operation cost $5.20 per Mbm with a return of at least $8 per Mbm or a net profit of $2.80 per Mbm.

In 1929, the Weyerhaeuser Timber Company in Klamath County, Oregon, brought between 4 and 500000 board feet of infested timber to their mill at a cost of about $5.06 per Mbm. On the basis of an $8 per Mbm log value at the mill, this operation yielded a profit of $2.94 per Mbm.

(5) Patterson, J. E. 1930. Milling beetle-killed pine timber. The Timberman; vol. xxxi; no. 3.

Records a detailed study of the milling of beetle-killed ponderosa pine during the period of May 9 - July 30, 1930 on 80 acres in southern Oregon.

Trees were yarded and loaded by horses and hauled by trucks. Beetle killed trees cut in 16-foot logs, scaled by Scribner Dec. C with average diameter under bark at small end and average diameter of heartwood at same end recorded separately. Logs sold on gross scale basis at 33-1/3% less than rate for green logs. On these 80 acres there were 47 trees or 51,430 board feet killed in 1926 and 1927. Of these trees, 16 were culled and 31 trees or 41,410 board feet were milled. Trees killed before 1926 were unmerchantable.

Patterson found that:

(1) Cost of logging these beetle-killed trees was 20% less than that of green timber (due to partial seasoning).

(2) Principal cause of deterioration of beetle-killed trees is blue sap stain, followed by checking, followed by decay of sapwood, and followed by wood-borer damage. Amount of sap stain dependent on amount of sapwood in trees. In trees salvaged, heartwood amounted to 59% of the volume.

(3) Of the trees killed in 1926 and 1927 on the area, 66% were salvaged and 80.5% of their volume utilized. After the second season of exposure trees were unmerchantable.

(4) Source of greatest proportion of cull was sap-rot which amounted to 19.5% of the gross volume.

(5) Made no check of recovery through mill, as operator did not cull the degraded stock or grade the unstained sapwood separately.

(6) Wagener, W. W. 1930. Degrade from blue stain and other fungi in insect-attacked western yellow pine, Modoc National Forest, California. Station Report April 7, 1930.

This study was limited to trees dead not more than one year but secured representative distribution of trees within this field. Recorded average diameter at small end and average width of sapwood for each log. The stains were estimated as a percentage of total sapwood for entire log.

Wagener found: (1) Two types of bluestain, one heavy and one light; (2) No correlation between diameter and percent of bluestain present; (3) Yellow sap stain present and scattered; (4) Sap rots common and of a type which continue to develop under favorable conditions after lumber is cut; (5) Trees with high percentages of heavy blue stain did not at the same time show heavy sap rot or yellow stain; and (6) Only the sapwood, which made up 3/5 of the log volume, affected by stains and rot.

His observations may be summarized as follows:

(1) Overwintering trees of previous year. Sapwood of all logs blue stained, 15-90% heavy stain in butt logs; considerable light blue stain throughout; moderate sap rot expected but absent in some trees; small amount of yellow stain; heartwood sound and bright.

(2) Main summer trees of current year. Sapwood of all logs blue stained, concentration of heavy stain in butt and sometimes in top; rest of bole with 1-10% heavy bluestain in scattered streaks; 40-50% in occasional logs; moderate to high percentage light bluestain in all logs; some sap rot in about 1/3 of logs; pronounced yellow stain in some trees; heartwood sound and bright.

(3) Late summer trees of current year. Sapwood of all logs blue stained, much variation tree to tree; 50% of logs with 10% or less scattered heavy stain, 13% with over 25% heavy stain; occasional sap rot in early stage; yellow stain prevalent; heartwood sound and bright.

(4) Early fall trees of current year. Sapwood of some upper logs not attacked; bluestain variable in rest, mostly heavy type; 25% of logs with over 20% heavy stain, in rest of logs mostly under 5%; no sap rot; no yellow stain; heartwood sound and bright.

(5) Late fall trees of current year. Sapwood of 33% of logs bright, rest with scattering small streaks heavy bluestain 1% or less; occasional log with concentration heavy stain; no sap rot; no yellow stain; heartwood sound and bright.

(7) Rumbold, Caroline T. 1931. Two blue-staining fungi associated with barkbeetle infestation of pines. Jour. Ag. Res. 43(10) 847-873.

Dr. Rumbold has shown that the bluestain fungus Ceratostomella pini Münch. is closely associated with the western pine beetle (Dendroctonus brevicomis Lec.). The heavy bluestain which develops in the infested trees soon after attack by Dendroctonus and Ips beetles results from the spread of the staining organism from the newly mined insect galleries. Its appearance and rate of spread appears to be correlated with insect species and brood development. The fungi are introduced at the time of attack and develop with the attack. This leaves no free time between the attack and the staining of the sapwood.

(8) Jaenicke, A. J. 1931. Logging of infested yellow pine as a method of brevicomis control. Station Memorandum. Feb. 10, 1931.

Mr. A. Bilodeau of Lapine, Oregon, logged beetle-infested and beetle-abandoned trees for Shevlin-Hixon Lumber Co. in vicinity of Lapine, Oregon, from June 1-November 30, 1930. He was paid $8 per M for logs delivered at the tracks. Because of bluestain, confined his cutting to trees over 22-24 inches. Company claims to have made no profit from these logs.

Mr. Bilodeau used a three-man crew, a 1½-ton Ford truck and trailer, and a team of horses. Horses skidded logs to the trucks. Loads varied from 1 - 2000 board feet and length of haul varied from 1-15 miles. Approximately $8,000 was paid for the project which covered 10,000 acres. Volume logged amounted to 1,200 M. bd. ft. and net scale after deducting for bluestain was 1,000 M. bd. ft. Logged 890 trees with an average volume of 1,120 bd. ft. and an average diameter of 30 inches. Trees averaged 56 per section. (36 abandoned trees and 20 infested trees).

(9) Brundage, M. R. and Orr, T. J. Jr. 1936. Lumber selling values of logs from insect infested ponderosa and Jeffrey pine trees salvaged in 1935 on an East-side pine region area. California Forest and Range Experiment Station Research Note, No. 9, April 10, 1936.

In the spring of 1935, the Forest Service and Bureau of Entomology and Plant Quarantine secured the cooperation of a large operator in the east-side pine region of California in conducting an experimental bug-tree salvage operation on approximately 6,000 acres. The main object was to determine the feasibility and effectiveness of salvage logging as an insect control measure. Most of the trees marked ranged from newly attacked to those containing pupal stages. No trees killed prior to 1934 were logged. About 450 logs covered by a mill production study. All boards were numbered. After seasoning (part in yard and part in kiln) lumber was graded rough dry by an inspector of Western Pine Association. Grade of each board without stain or defects attributable to insects was recorded as well as final grade after allowances. Both sets of grades evaluated by application of 1935 lumber selling prices. Logs divided into 4 insect-stain classes which were about the same as the salvage classes. Logs were graded at the mill deck on surface appearance (as they would have been if uninfested by insects).

Article has 7 tables comparing ponderosa and Jeffrey pine realization values of logs of the same external grade appearance, insect-stain class, and log-diameter groups. The depreciation percent of logs with insect infestation over those with normal defects ranged from 0% to 44%. The spread in these percentages by insect-stain classes and log grades was as follows:

	Insect-stain class		
Log grades	New attacks and egg stage	Small and large larvae	Mostly pupae and beyond
1. Surface clear logs	.3 - 7.2%	17.7%	38.1%
2A. High class Shop type logs	.3 - 4.9%	16.2%	30.9%
2B. Medium class Shop type logs	.7 - 9.8%	17.6%	25.6%
3. Common type logs--small red knots	0 - 4.9%	14.0%	18.3%
4A. #3 Shop, #3 Common large knotted type, Common type--small dead knots	.6 - 6.9%	12.0%	20.4%
4B. Large knotted, rough logs	2.3%	—	18.0%

(10) Johnson, P. C. 1940. Entomological considerations in utilization of insect-killed ponderosa pine. Jour. Econ. Entom. 33(5) 773-776.

Presents the results of a study of the entomological aspects of this salvage problem.

Two studies were conducted; one on 8,000 acres of pure ponderosa pine in Shasta County, California, and the other on 6,000 acres of mixed ponderosa and Jeffrey pine in Lassen County, California. On each area, the currently infested trees were located and marked for cutting. After the trees were felled a complete analysis was made of each bole on one 320-acre plot in each area to determine the location and amount of bark surface occupied by various stages of infesting insect species.

The main objectives of these studies were (1) to determine the relationship between barkbeetle development and blue staining and (2) the control effect of the salvage operations.

The infestation patterns made from bole examinations of felled infested trees were used in demonstrating a significant correlation between the blue staining and the insect species present, and between the staining and brood development. Degrade from blue staining amounted to as high as 50 per cent in trees containing advanced broods of Dendroctonus, Ips, and Melanophila spp.

A decline of 40 per cent in infestation the year following salvage was noted. Infestations in check areas for the same period remained unchanged or slightly increased. The reduction in loss obtained on the salvage area was approximately the same as that following a direct control project accomplished under very similar conditions on a nearby area.

II. WHAT WE KNOW OF THE DETERIORATION AND SALVAGE OF INSECT-KILLED PONDEROSA PINE TREES.

A. Causes of deterioration

1. The stages in the deterioration of insect-killed ponderosa pine trees and logs are:

(a) Introduction of sap-staining fungi by attacking insects

(b) Development and spread of sap staining fungi

(c) Checking of sapwood and heartwood

(d) Development of fungi resulting in the decay of the sapwood and heartwood

(e) Damage of both sapwood and heartwood by wood boring insects

(f) Final reduction and decomposition of wood.

2. At the time the trees are attacked, spores of sap-staining fungi are introduced. The development and spread of these fungi result in the staining of the sapwood. (Rumbold).

3. The chief cause for degrade in recently killed ponderosa pine trees and logs is sap stain, particularly bluestain. The amount of sap staining is dependent on the amount of sapwood (Patterson).

4. There are two types of blue staining; a heavy and a light staining. Concentrations of heavy stains commonly found in the sapwood at the base of the trees and extending nearly through the butt log. (Wagener).

5. The chief cause for cull of insect-killed ponderosa pine trees and logs is sap rot. (Patterson). Once established, the sap-rotting fungi develop rapidly from narrow longitudinal streaks into irregular patches and in time the entire cross section of the sapwood becomes involved. (Wagener).

6. Trees and logs with high percentages of blue stains do not at the same time show heavy sap rots, and conversely trees and logs with low percentages of blue stains show high percentages of sap rots. (Wagener).

7. Greatest deterioration occurs during the growing season. (Boyce).

B. Salvage during year of attack

I was unable to find records of the percentage of the total year's loss salvaged during the year of attack; most of the records showing the percentages salvaged the year following attacks or during the first season of exposure.

1. In reporting on the condition of currently infested trees, Wagener offers the following:

(a) Main summer trees. Sapwood of all logs blue-stained; some sap rot in about 1/3 of logs; pronounced yellow stain in some trees; heartwood sound and bright.

(b) Late summer trees. Sapwood of all logs blue-stained; occasional sap rot in early stage; yellow stain prevalent; heartwood sound and bright.

(c) Early fall trees. Sapwood of some upper logs not attacked, bluestain variable in rest; no sap rot; no yellow stain; heartwood sound and bright.

(d) Late fall trees. Sapwood of 1/3 logs bright; no sap rot; no yellow stain; heartwood sound and bright.

2. Jaenicke states that between June and November trees above 22 inches were salvaged which averaged 20 infested and 36 abandoned trees per section. (These records cannot be converted to show the percentage of total year's loss that was salvaged.)

3. Degrade from blue staining amounts to as high as 50% in trees containing advanced broods of bark beetles. (Wagener and Johnson).

4. It is reasonable to expect that, except for a degrade of blue-stained sapwood, practically all insect-killed ponderosa pine trees should be considered salvageable during the year of attack.

C. Salvage during first season of exposure

1. The salvage of 90% of the trees and 93.3% of the volume killed the year before logging has been reported. Of this loss, 100% of the volume and number of winter trees and 86.4% of the volume and 82% of the number of summer trees were salvaged. (Patterson).

2. In trees treated by the fell-peel-burn method of control an average of 87% of the volume remained salvageable at the end of the first season of exposure. This represents an average cull of 18%. (Boyce).

3. Of the 145,000 square feet of bark surface included in trees marked for salvage on two 320-acre check plots, 15% was uninfested, 68% infested and 17% abandoned. The salvaged material removed from the woods included approximately 94% of the uninfested and 90% of the infested bark. (Johnson). (This study was made in the spring and summer of 1935 and Johnson states that most of the 1934 winter trees and early summer trees were removed from the woods. Hence it is taken that most of the material salvaged was in its first season of exposure.)

B. Salvage during second season of exposure

1. The salvage of 64% of the volume and 48% of the number of trees killed two years before logging has been possible. Of this loss, 47.7% of the volume and 55% of the number of summer trees, and 73.2% of the volume and 44% of the winter trees were salvaged. (Patterson).

2. In trees treated by the fell-peel-burn method of control, only 40% of the volume remained salvageable at the end of the second season of exposure. This represents an average cull of 60%. (Boyce).

E. Salvage during third season of exposure

1. In the only operation studied, trees exposed for three seasons were so badly deteriorated that they would not defray logging costs and were considered as culls. (Patterson).

2. Trees treated by the fell-peel-burn method of control were 25% salvageable (or 75% cull) during the third season of exposure. (Boyce).

F. Salvage after third season of exposure

1. The only data available for the condition of insect-killed ponderosa pine trees after the third season of exposure are for trees treated by the fell-peel-burn method of control. These data, by Boyce, show:

Seasons of exposure	Percent Salvageable	Cull
4	19%	81%
5	15%	85%
6	12%	88%
7	8%	92%

G. Mill recovery

1. Percent of depreciation in lumber realization values of insect-killed ponderosa pine logs over logs with normal defects ranges from 0 - 44% in trees during the first season of exposure. The spread in these percentages was found to be:

Insect-stain class	Depreciation percent
New attacks and egg stage	0 - 9.8%
Small larvae and large larvae	12.0 -17.6%
Mostly pupae and beyond	18.0 -38.1%

(Brundage and Orr).

2. It has been inferred that from the better grades of logs without excessive degrade, a fair margin above logging and milling costs can be made on most operations. (Brundage and Orr).

3. Records are not available on the milling of and the recovery from insect-killed ponderosa pine trees exposed for more than one season.

4. An analysis by J. R. Berry (In U. S. Forest Service memorandum to Fruit Growers Supply Company, dated July 24, 1935) is reported by Johnson as giving gross scale degrade resulting from blue staining as estimated by a scaler. (A copy of this report is not in the files of the Portland laboratory.)

H. Cost of logging insect-killed ponderosa pine trees

1. When insect-killed ponderosa pine trees are logged in conjunction with green trees, the cost of logging the former trees has been found to be 20% less than that of green timber. This was due to a partial seasoning before the trees were felled and was reflected in lower yarding, loading, and hauling costs. (Patterson).

2. The absence of heavy foliage on insect-killed trees makes for less swamping around the felled trees. (Patterson).

3. The breakage factor in felling insect-killed trees is greater than in green trees. A high percentage of insect-killed trees throw their tops even on smooth ground. (Patterson).

4. Because most insect-killed trees throw the bark from the lower trunk, yarding is facilitated by the slick surface but loading is more difficult due to the tendency of the logs to slip on the skids and bunks. (Patterson).

5. In 1923, Weyerhaeuser Timber Company sold the logs left in the woods after the completion of a fell-peel-burn control project. A contractor hauled the logs 5 miles to a small mill and paid $1 for the logs taken. The operation was not profitable. (Keen (4)).

6. The Weyerhaeuser Timber Company also purchased a small portable sawmill and tried sawing the logs felled in a fell-peel-burn control project into lumber and hauling the lumber to the nearest market. Because the logs were so widely scattered, frequent sawmill moves were necessary and the operation proved to be unprofitable. (Keen (4)).

7. The following table summarizes the comparative data from several salvage operations:

Cost of Salvaging Insect-Killed Ponderosa Pine Logs

Company	Pickering Lumber Co.	McCloud River Lumber Co.	Weyerhaeuser Timber Co.	Shevlin-Hixon Lumber Co.
Location of operation	Modoc Co., Calif.	Modoc Co., Calif.	Klamath Co., Oregon	Deschutes Co., Oregon
Year	1928	1929	1929	1930
Kind of logs	Beetle-infested	Beetle-infested	Beetle-infested	36% beetle-infested. 64% beetle-abandoned
Acreage covered	10,760 acres	A strip 2 miles on each side of railroad tracks	(?)	10,000 acres
Volume logged	2,00 Mbm	1,000 Mbm	4-500,000 bd. ft.	1,200 Mbm
Cost of logs at mill	$6.58 per Mbm	$5.20 per Mbm	$5.06 per Mbm	$8 per Mbm (plus hauling costs)
Value of logs at mill	$8 per Mbm (50% of value of green logs)	$8 per Mbm	$8 per Mbm	(?)
Profit	$1.42 per Mbm	$2.80 per Mbm	$2.94 per Mbm	No profit claimed

8. In 1930 Patterson sold the logs from 31 insect-killed ponderosa pine trees on a gross-scale basis of 33 % less than the green pine rate. (Patterson).

III. WHAT WE NEED TO KNOW ABOUT THE DETERIORATION AND SALVAGE OF INSECT-KILLED PONDEROSA PINE TREES

(1) What is the rate of deterioration of insect-killed ponderosa pine trees in each of Keen's tree classes 1 year, 2 years, 3 years, 4 years, etc., after death?

(a) What are the salvageable diameter limits of these trees?

(b) What is the average number of 16-foot logs that may be salvaged from these trees?

(c) What percent of the total log volume of these trees should be degraded or culled?

(2) What recovery of lumber may be expected from insect-killed ponderosa pine trees in each of Keen's tree classes 1, 2, 3, 4, etc., years after death?

(a) What grades of lumber can be cut from these trees?

(b) What percent of the total vlume of each log does this recovery represent?

IV. ARTICLES PERTAINING TO THE DETERIORATION AND THE SALVAGE OF INSECT-KILLED PONDEROSA PINE TREES

(1) Boyce, J. S. 1923. The deterioration of felled western yellow pine on insect-control projects. U. S. Department of Agriculture Bulletin 1140.

(2) Keen, F. P. 1929. Report of insect control work carried out by Pickering Lumber Company on the Badger Sale Area, Modoc National Forest, California during the season of 1928-1929. Station Report. August 13, 1929.

(3) _____ 1929. Western pine beetle survey Happy Camp-Lava Bed Area, Modoc National Forest, California, 8th Annual Report. Station Report. Dec. 18, 1929.

(4) _____ 1932. Pine beetle control costs reduced through logging and salvage. United States Department of Agriculture Yearbook of Agriculture 1931; pp. 428-430.

(5) Patterson, J. E. 1930. Milling beetle-killed pine timber. The Timberman Vol. XXXi, no. 3, pp. 162-172.

(6) Wagener, W. W. 1930. Degrade from blue stain and other fungi in insect-killed western yellow pine, Modoc National Forest, California, Station Report April 7, 1930.

(7) Jaenicke, A. J. 1931. Logging of infested yellow pine as a method of brevicomis control. Station Memorandum Feb. 10, 1931.

(8) Rumbold, Caroline T. 1931. Two blue-staining fungi associated with barkbeetle infestation of pines. Journal of Agricultural Research. Vol. 43, no. 10, pp. 847-873.

(9) Brundage, M. R. and Orr, T. J., Jr. 1936, Lumber selling values of logs from infested ponderosa and Jeffrey pine trees salvaged in 1935 on an East-side pine region area. California Forest and Range Experiment Station Research Note. no. 9, April 10, 1936.

(10) Johnson, P. C. 1940. Entomological considerations in utilization of insect-killed ponderosa pine. Journal of Economic Entomology. Vol. 33, no. 5, pp. 773-776.